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Magnetic Field Exposure Effect on Water Properties and its Effect on Pumpkin(*Cucurbita moschata Duchesne*) and Okra (*Abelmoschus esculentus Moench*) Seedling Growth Performance

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ABSTRACT

KEY WORDS:

Water; Magnetization; Okra; Pumpkin; Growth

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This study aims to understand the effect of magnetic field on water properties and plants growth performance. Magnetic water is produced when water is passed through a magnetic field which alters the state of water macromolecules. The changes to physico-chemical properties of magnetized water affect the biological properties of organisms. This experiment was conducted at a greenhouse in the Institute Sustainable Agrotechnology (INSAT) experimental farm, Universiti Malaysia Perlis, Padang Besar, Perlis, Malaysia. It carried out according to Randomize Complete Block Design (RCBD) with four replications. The magnetic field was applied on water to evaluate through three different intensities; 0.10, 0.15, and 0.20 Tesla, in addition to control treatment (without magnetic) for seedling growth of pumpkin (CV. Labu Loceng) and okra (CV. Bendi Alabama). The morphological study of water and study of seedling height, stem diameter, leaf numbers, seedling weight and dry weight of seedling are researched. The magnetic water at 0.20 Tesla had significantly increases in the leaf number per seedling 6.000 leaf seedling⁻¹ and dry seedling weight 0.5700 g of pumpkin. Meanwhile, the magnetic water at 0.20 Tesla increased significantly in seedling height, stem diameter, leaf number per seedling, seedling weight and dry seedling weight of okra reached to 13.750 cm, 2.677 mm, 5.500 leaf seedling⁻¹, 1.7800 g and 0.3369 g, respectively compared to control.

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تأثير التعرض للمجال المغناطيسي على خواص الماء و نمو شتلات القرع (*Cucurbita pepo*) و الباميا (*Abelmoschus esculentus*)

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الخلاصة

هدفت هذه الدراسة إلى فهم تأثير المجال المغناطيسي على خصائص الماء و نمو النباتات. ينتج الماء المغناطيسي عندما يمر الماء عبر مجال مغناطيسي يغير حالة جزيئات الماء. تؤثر التغييرات التي تطرأ على الخواص الفيزيائية والكيميائية للمياه المغنطة على الخصائص البيولوجية للكائنات الحية. أجريت هذه التجربة في مزرعة معهد التكنولوجيا الزراعية المستدامة التجريبية، جامعة ماليزيا بيرليس، بادانج بيسار، بيرليس، ماليزيا. تم تنفيذ التجربة وفقاً لتصميم القطاعات العشوائية الكاملة (RCBD) بأربعة مكررات. تم تطبيق المجال المغناطيسي على الماء للتقييم من خلال ثلاث شدة مختلفة ؛ 0.10 و 0.15 و 0.20 تسلا ، بالإضافة إلى معاملة المقارنة لنمو شتلات اليقطين والباميا. تم البحث في الدراسة المورفولوجية للمياه ودراسة طول النبات وقطر الساق وعدد الأوراق ووزن النبات والوزن الجاف للنبات. أدى الماء المغناطيسي عند 0.20 تسلا إلى زيادة معنوية في نمو الشتلات لجميع النباتات المختبرة ماعدا وزن النبات مقارنة بالسيطرة. اما ما يخص نمو الشتلات، فقد اعطت شتلات الباميا انخفاضا معنويًا في جميع الصفات مقارنة بشتلات القرع. حدث هذا الاختلاف نتيجة لتأثير الشد المغناطيسية والسلوك التفاضلي للمحاصيل استجابةً للماء المغنط. أدت معاملة الماء المغنط عند 0.20 تسلا كان له زيادة معنوية في عدد الأوراق لكل شتلة 6.000 ورقة شتلة¹ ووزن شتلة جافة 0.5700 غم من اليقطين. وفي الوقت نفسه ، اعطت معاملة الماء المغنط عند 0.20 تسلا زيادة كبيرة في ارتفاع الشتلة وقطر الساق وعدد الأوراق لكل شتلة ووزن الشتلة ووزن الشتلة الجافة في الباميا، إذ بلغت 13.750 سم و 2.677 ملم و 5.500 ورقة شتلة¹ و 1.7800 غم و 0.3369 غم، على التوالي مقارنة بمعاملة المقارنة.

الكلمات المفتاحية: ماء؛ مغنطة؛ باميا؛ قرع؛ نمو

INTRODUCTION

Plant growth is accelerated by magnetic fields, which is good for the agricultural industry. The use of magnetized treated water for irrigation can increase agricultural output, plant growth both quantitatively and qualitatively, seed germination, seedling vegetative growth, and the mineral content of seeds and fruits. As a result, one of the most potential uses of a magnetic field to boost agricultural production in the future could be through the magnetization of treated water. In dry and semiarid areas, magnetizing treated water may have a growth-inducing impact depending on the water's quality, ion content, and magnetization method. This kind of physical therapy aids in avoiding the usage of pricey synthetic materials like polyphosphates or corrosive compounds that can harm people or disturb the environment (Abobatta, 2019).

At the same time as water use is becoming a more significant global concern and there is a need for more food from fewer water resources, agriculture in arid and semiarid countries is currently impacted by a lack of fresh water and a noticeable increase in salt salinity soil and subterranean water. One promising method to improve agricultural productivity and water quality is to magnetize treated water (Hussain et al., 2019).

Due to the current water shortage, agricultural water input per unit area will need to be decreased, increasing competition from other sectors of the water industry (Surendran et al., 2014, 2016). Water resources are continually under stress for a variety of causes, necessitating a scientific strategy to maintain agricultural crop growth. In addition, due to issues with water quality and a lack

of excellent quality water, the use of low-quality irrigation water, excessive salinity, hardness, and waste water is becoming more popular in many nations. As a result, contemporary agriculture is currently looking for an effective eco-friendly production system to increase crop productivity without endangering the environment.

The use of magnets to clean water dates back a long time (Zaidi et al., 2014). The first magnetic water treatment system to be used commercially is patented by (Vemeiren, 1958). Despite the fact that the magnetic effect is minimal, researchers are still attempting to employ it in various domains due to its potential for practical applications (Amiri and Dadkhah, 2006; Chang and Weng, 2006; Pang and Deng, 2008). As a result, magnetized water has many uses in business, agriculture, and medicine (Fathi et al., 2006; Kney and Parsons, 2006; Maheshwari and Grewal, 2009; Selim and El-Nady, 2011; Teixeira da Silva and Dobránszki, 2014, 2016). According to the review by Teixeira da Silva and Dobránszki (2014) and Zaidi et al. (2014), there have been reports of the practical use of magnetic fields in agriculture, including seed treatment, germination studies, seedling development, and crop yields for a variety of species, including fodder and industrial crops as well as agricultural, horticultural, and medicinal plants. Numerous magnetic field (MF) characteristics, including polarity, intensity, exposure duration, and magnet type, have an impact on how plants grow and develop. Before proceeding on a bigger scale, each MF should be examined individually because the reported effects were invariably genotype-dependent. However, the majority of these investigations used a static magnetic field on seed (Tanaka et al., 2010). Magnetized water can, however, enhance the qualities of water and crop productivity, according to certain research that have used it (Maheshwari and Grewal, 2009; Hassan et al., 2019; Hassan et al., 2021). These results imply the possibility of employing magnetic water treatment to increase crop productivity even while using water of low quality.

If we look at the long term costs and environmental safety of using magnetic field treatment to enhance plant development, it is not so expensive. Due to water scarcity, both spatially and temporally, in the context of climate change-related impacts of drought, the usage of low-quality water is also becoming more and more common. It has been noted here that several closely related studies carried out in numerous nations have reported on some positive benefits of magnetic field. Although additional research is required in many regions of the world, irrigation with magnetized treated water is another unique element of using magnetic fields to improve crop growth and development. Different animals respond differently to magnetic field intensity. The best magnetic field intensity to improve water quality must thus be studied, as this would subsequently have an impact on plant productivity (Hassan, 2018a). Trials must be conducted to determine the perfect intensity for a species and at which growth stage. Several studies showed positive effect of magnetic water on seed germination and crop growth (Phirke et al., 1996; Vashisth and Nagarajan, 2010; Naz et al., 2012).

The study's findings offer guidance for enhancing MWT irrigation management practices, particularly for the growth of pumpkin and okra seedlings. Irrigation with magnetizing treated water is another special aspect of using magnetic fields for improving crop growth and development, although need more experiment in different areas around the world. The objective of this study to investigate the effect of magnetic field on seedlings growth of pumpkin and okra.

MATERIALS AND METHODS

The experiment was carried out from 6 Dec. to 26 Dec. 2016 at a greenhouse in the Institute Sustainable Agrotechnology (INSAT) experimental farm, Universiti Malaysia Perlis, Padang Besar, Perlis, Malaysia. The farm is located at 6.653 °N and 100.261 °E. The loamy sand soil was used for the experiment setup. Samples of local variety of pumpkin (CV. Labu Loceng) and okra (CV. Bendi Alabama) seeds were provided by the Perlis agriculture office. Seed was split into two groups, one for the control samples and the other for the treatment samples. Pumpkin and okra seeds were sown in seedling trays. The samples had identical growing and harvesting conditions; they were just watered with magnetic water samples, whereas the control samples received merely regular tap water

treatment. To investigate the impact of magnetized water on the growth of pumpkin and okra seedlings, seedling growth was carried out in a greenhouse with natural light and an average temperature of 33 °C. Random samples of pumpkin and okra that were harvested on Dec. 26 were gathered and taken to the biosystem Engineering laboratory.

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The Magnetic devices

A half-inch polyvinyl chloride (PVC) pipe with magnetic plates attached to each side make up each device. An instrument called a Gauss meter (FW Bell: 5170 Gauss/Tesla meter, USA), whose values are represented in Gauss, where 1 Gauss is equal to 10^{-4} T or 100 microT (T), was used to evaluate the strength density of the magnet inside the PVC pipes of magnetic devices. Magnet pieces are attached to the walls of a PVC water pipe to create the gadget. The strength of the magnets affects the strength of magnetic fields. Two parts of varying magnet intensities were utilized to create a magnetic field of three distinct intensities: 0.10, 0.15, and 0.20 T. Table 1 presents the dimensions of the magnetic devices fabricated in this study, while Figure 1 shows the magnetic devices used in this study.

Table 1 Dimensions of the magnetic devices of varying intensities.

Magnetic device intensity (T)	Length (cm)	Circumstance (cm)	Diameter (cm)
0.10	29	19	6
0.15	25	25	8
0.20	25	25	8



Figure 1 The magnetic devices of different intensities used in the experiment (a) 0.10 T (b) 0.15 T(c) 0.20 T.

Magnetic field effect on water quality

The magnetic field effect of intensities; 0.10, 0.15, and 0.20 T on water quality were analysed. The Hydrolab (DS5 HACH Environmental) used to measure water pH, total dissolved salts (TDS), Conductivity (CD), Salinity/ ppt and turbidity in the untreated/treated water.

Growth conditions

The study of the growth parameters from the four replicated experiments with complete randomization provided a summary of the growth parameters. The morphological study of water and study of seedling height, stem diameter, leaf numbers, seedling weight and dry weight of seedling are researched. The dry matter weight of the shoot seedling was measured after the seedlings were removed from the soil and cleaned to remove any remaining loose soil, 20 days after sowing. The height of the seedling was measured using a ruler with an accuracy of 0.1 cm, and the weight of the shoot seedling was measured. After that, the seedlings were dried overnight at a temperature of 70 °C on medium heat until the weight remained constant.

Statistical procedures

The experiment was designed according to Randomized Complete Block Design (RCBD) (0.10, 0.15, 0.20 Tesla and control) and replicated four times. The analysis of variance was carried out using SAS program (version 9). Mean values were separated based on Duncan's at 0.05 probability levels.

RESULT AND DISCUSSION

Water properties

There is a significant difference among the control and other magnetic field intensities treatments in water pH and turbidity exposure to 0.10, 0.15, 0.20 Tesla compare with control treatment. The results show no significant effect for total dissolved salts (mg.L^{-1}) and Turbidity for the other treatments as illustrated in the Table 2.

Table 2 The mean ($\pm$ SD) of different water quality parameters of pumpkin and okra various magnetic field intensities.

Parameters Treatments	pH	TDS mg/L	Conductivity us/cm	Salinity/ ppt	Turbidity
Control	8.6 $\pm$ 0.03 b	180.5 $\pm$ 0.36 a	283.3 $\pm$ 0.86 c	0.13 $\pm$ 0 a	0.83 $\pm$ 0.5 bc
0.10 T	8.7 $\pm$ 0.01 a	179.7 $\pm$ 0.47 a	284.2 $\pm$ 0.24 bc	0.13 $\pm$ 0 a	0.84 $\pm$ 0.5 b
0.15 T	8.7 $\pm$ 0.01 a	179.0 $\pm$ 0.45 a	285.4 $\pm$ 0.35 bc	0.13 $\pm$ 0 a	0.8 $\pm$ 0.2 bc
0.20 T	8.7 $\pm$ 0.03 a	178.8 $\pm$ 0.5 a	285.6 $\pm$ 0.73 bc	0.13 $\pm$ 0 a	0.79 $\pm$ 0.3 c

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division.

Morphological study

Through the use of field emission-scanning electron microscopy (FE-SEM), the morphology of nanoscale water is examined. Figure 2 displays FE-SEM pictures of water at the nanoscale for various magnetic strengths. Figures 2(a) through (c) depict uniform surface morphology over the entire substrate as shown by holes or cracks, while Figure 2(d) displays emergent features such compact and tightly packed morphology. A granular nanostructure with few breaks is produced by the tap water. Figure 2 further demonstrates that the size of the water grains grows as intensity rises, with the exception of 0.20 T, which signals an increase in film crystallinity. The measured average grain sizes for tap water are 14.56 nm, 15.53 nm, 16.08 nm, and 10.57 nm for 0.10 T, 0.15 T, and 0.20 T, respectively. It is interesting that nanostructures' aspect ratio rises from an average of 14 to 16 nm (Figure 2). This phenomenon can most likely be explained by increased intensity reactivity when compared to tap water, which leads to faster formation and subsequent kinetics-driven growth. It is common knowledge that grain size affects industrial efficiency, hence larger grains are necessary for efficient applications. To adjust surface wettability experimentally, an electric field can be applied. The ability to alter the interfacial properties of water using an electric field is constrained by the decreasing experimental length scales and the need to understand unique nanoscale effects (Al-Douri et al., 2021; Al-Douri et al., 2022).

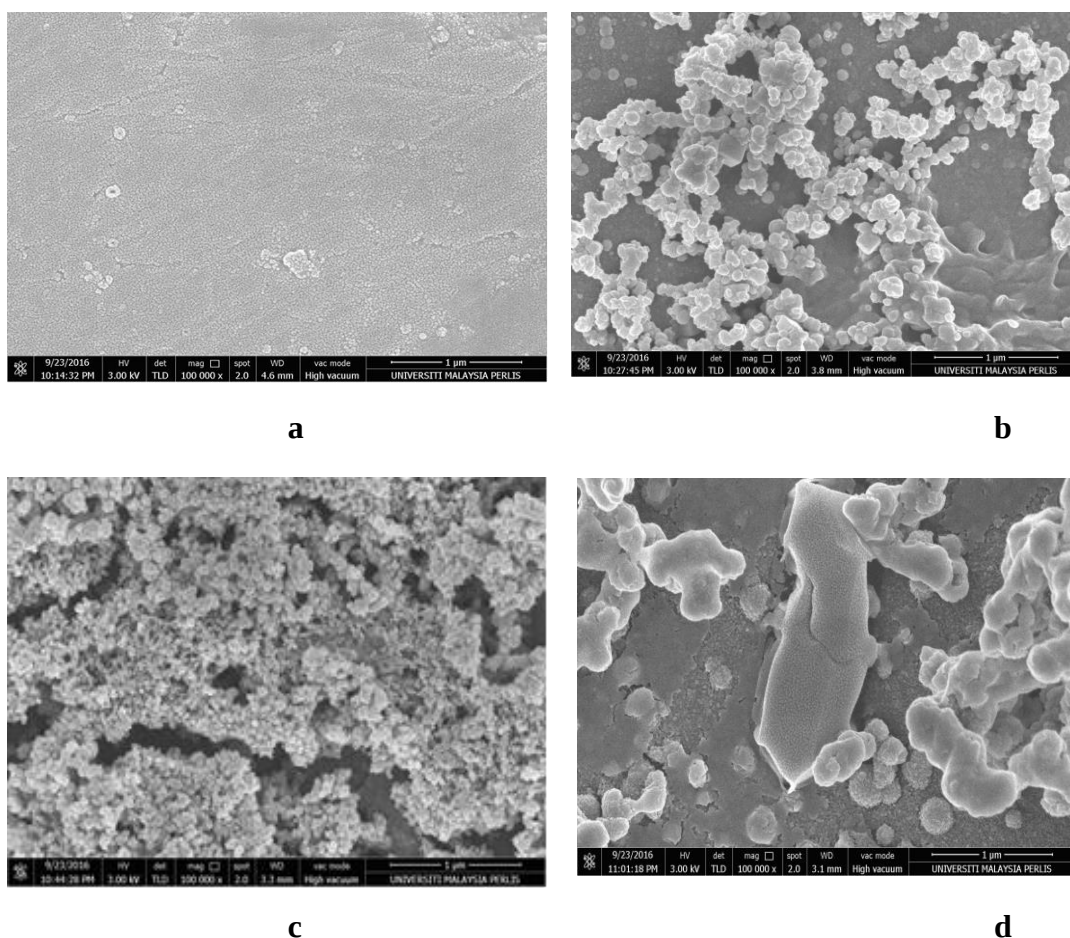


Figure 2 FE-SEM images of water nanomolecule (a) Tap water, (b) 0.10 T, (c) 0.15 T, (d) 0.20 T.

Magnetized water effect on seedling height of pumpkin and okra

As Table 3, the effect of water magnetized in seedling height of pumpkin wasn't significant.

Table 3 The mean ($\pm$ SD) of magnetized water effect on seedling height (cm) of pumpkin and okra

Treatment	Control	0.10 T	0.15 T	0.20 T
Pumpkin	20.975 $\pm$ 1.545 a	20.425 $\pm$ 1.584 a	19.175 $\pm$ 5.611 a	20.525 $\pm$ 4.012 a
Okra	10.000 $\pm$ 2.415 c	12.750 $\pm$ 0.957 ab	11.000 $\pm$ 5.005 bc	13.750 $\pm$ 1.322 a

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division.

On the other hand, the highest seedling height of okra was detected to be 13.750 cm in water magnetized at 0.20 Tesla followed by 12.750 cm at 0.10 Tesla and 11.000 cm at 0.15 Tesla, while the least highest of seedling was obtained 10.000 cm at the untreated water.

Magnetized water effect on stem diameter of pumpkin and okra

Table 4 illustrates the different magnetic field effect on the stem diameter. The stem diameter of pumpkin seedling isn't significantly increased by using the magnetic field in water, compared with the untreated irrigation water.

Table 4 The mean ($\pm$ SD) of magnetized water on stem diameter (mm) of pumpkin and okra.

Treatment	Control	0.10 T	0.15 T	0.20 T
Pumpkin	3.752 $\pm$ 0.089 a	3.865 $\pm$ 0.355 a	3.665 $\pm$ 0.615 a	3.900 $\pm$ 0.805 a
Okra	2.102 $\pm$ 0.258 b	2.757 $\pm$ 0.189 a	2.550 $\pm$ 0.887 ab	2.677 $\pm$ 0.466 a

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division.

On contrast, the stem diameter in the okra seedlings varied from 2.757 mm under 0.10 Tesla treatment to 2.102 mm for untreated irrigation water. The stem diameter in the okra seedlings under different treatments in decreasing order was 0.10 Tesla > 0.20 Tesla > 0.15 Tesla > untreated irrigation water.

Magnetized water effect on leaf numbers of pumpkin and okra

In the present study, it is observed that magnetic water treatment has a statistically significant effect in terms of leaf numbers (pumpkin and okra) (Table 5). The application of magnetic water treatment to the seedlings significantly restored leaf numbers compared to the seedlings treated with normal water alone. In addition, morphological components such as seedling height and stem diameter were found to be mostly influenced under normal water conditions and magnetic water treatment (Tables 5 and 6).

Table 5 The mean ($\pm$ SD) of magnetized water on leaf numbers of pumpkin and okra.

Treatment	Control	0.10 T	0.15 T	0.20 T
Pumpkin	5.100 $\pm$ 0.476 b	5.750 $\pm$ 0.500 a	5.500 $\pm$ 0.774 ab	6.000 $\pm$ 0.432 a
Okra	4.750 $\pm$ 0.500 b	5.500 $\pm$ 0.577 a	4.750 $\pm$ 1.075 b	5.500 $\pm$ 0.577 a

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division

The leaf numbers increased significantly in the pumpkin seedlings with magnetic water application at 2.0 Tesla which was 6.000 leaf seedling⁻¹, but it is not significantly different with other treatments except untreated water. Also, the leaf numbers increased significantly in the okra seedlings with magnetic water treatments 0.20 and 0.10 Tesla reached to 5.500 leaf seedling⁻¹, whereas least value of leaf numbers in okra seedlings reached to 4.750 leaf seedling⁻¹ at magnetic water treatment 0.15 Tesla and untreated water (control treatment).

Magnetized water effect on seedling weight of pumpkin and okra

There was not significantly different in seedling weight of pumpkin between magnetic water treatments and untreated water (Table 6).

Table 6 The mean ($\pm$ SD) of magnetized water on seedling weight (g) of pumpkin and okra.

Treatment	Control	0.10	0.15	0.20
Pumpkin	3.2000 $\pm$ 0.3915 a	4.0350 $\pm$ 1.2417 a	3.4050 $\pm$ 1.6289 a	3.9750 $\pm$ 1.3419 a
Okra	1.1125 $\pm$ 0.4441 b	1.7800 $\pm$ 0.4048 a	1.2175 $\pm$ 1.8824 b	1.7800 $\pm$ 0.4843 a

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division.

Whereas, seedling weight increased significantly in okra seedlings by 60% at magnetic water treatment 0.20 Tesla, as compared to untreated water seedlings. While there is no significant

differences between the magnetized water treatments 0.20 and 0.10 Tesla, also between the untreated water treatment and the magnetized water at 0.15 Tesla (Table 6).

Magnetized water effect on dry seedling weight of pumpkin and okra

The results pertaining to dry seedling weight a significant difference ($P \leq 0.05$) among the treatments (Table 7). In the twentieth day after planting pumpkin the highest dry seedling weight of 0.5700 g was obtained from water magnetic 0.20 Tesla, followed by 0.10 Tesla 0.5467 g then 0.10 Tesla 0.5449 g, whereas the lowest dry seedling weight was obtained from untreated water 0.4454 g.

Table 7 The mean ($\pm$ SD) of magnetized water on dry seedling weight (g) of pumpkin and okra.

Treatment	Control	0.10 T	0.15 T	0.20 T
Pumpkin	0.4454 $\pm$ 0.0559 b	0.5467 $\pm$ 0.1545 a	0.5449 $\pm$ 0.2445 a	0.5700 $\pm$ 0.1336 a
Okra	0.1783 $\pm$ 0.0857 b	0.3192 $\pm$ 0.0607 a	0.2012 $\pm$ 0.2543 b	0.3369 $\pm$ 0.0854 a

* Means in a column under any given treatment followed by the same letter(s) do not differ significantly at 0.05 level of probability using the Duncan Multiple Range Test (DMRT).

($\pm$) Standard division

There was also a statistically significant difference between water magnetic treatments and untreated water for okra seedlings. Data presented in Table 7 have showed that water magnetic treatment at 0.20 and 0.10 Tesla led to statistical increases in the dry seedling weight 0.3369 g and 0.3192 g, respectively compared to magnetic treatment at 0.15 Tesla and untreated water 0.2012 g and 0.1783 g respectively.

The biological characteristics of the organisms that ingest or are exposed to magnetized water are impacted by changes in the physico-chemical properties of the liquid. There are several water characteristics that affect farm production on where any change in these variables could have a fundamental impact on the growth performance (Hassan et al., 2021; Hassan et al., 2022). The impact was discovered to depend on the durations and intensities of the magnetic field exposure, which alters the structure of the water molecule and the permeability pressure (Abdel Tawab et al, 2011). According to Joshi et al. (1996), the magnetic field has an impact on the hydrogen bonds forming between water molecules, changing the pH. On the other hand, according to Alkhazan and Saddiq (2010), the rearranging of the water molecules into one direction when water is exposed to a magnetic field softens the water and raises its pH. Hasaani et al. (2015), who noted a 12% rise in water pH after magnetization, provided evidence for this. The metabolism and other physiological systems are impacted by pH. (Soundarapandian and Saravanakumar, 2009). The findings concur with those published by Ni'am et al. (2006); Gilani et al. (2014); Hasaani et al. (2015). By changing the water's nucleus, researchers showed that exposure to magnetic field influences the molecular and physico-chemical characteristics of water (Coey and Cass, 2000; Cai et al., 2009). The increased solubility of salts is due to the fact that when water is exposed to dipole magnetic fields, some of its physico-chemical characteristics change, but the dipole magnetic qualities are preserved thanks to the dissolved minerals. According to Abdel Hady et al. (2011), this is caused by a change in the water

molecules' electric dipole, which is connected to a change in the CD as a whole. This contradicts the findings of Hasaani et al. (2015), who discovered a 16% decrease in CD post-exposure, and Alkhazan and Saddiq (2010), who saw an increase in CD post-exposure. The magnetized field's transformation of water's molecular structure, from bigger to smaller molecules, is thought to be the cause of the increase in EC. By converting a regular water quintet installation into an efficient water installation hexagon under the influence of magnetism, ordinary water becomes more permeable to body cells and tissues and has a higher electrical conductivity (EC) (Al-Ibady, 2015).

For irrigation water, a magnetic field between 3.5 and 136 mT boosted the soil's electric conductivity (Maheshwari and Grewal, 2009). The transition character of the electrons within the water molecules changed as a result of these alterations (Pang and Deng, 2008). These tiny structural components are actually tiny representative magnets since water has several molecule structures that can be magnetized by an external magnetic field. However, compared to non-magnetized water, post-magnetization molecules' polarized characteristics and transition of their dipole moments are improved (Pang and Bo, 2009).

The water molecules are more excited as a result of the device's varying polarity and intensity, which more effectively rearranges their clusters. Other factors to take into account are the water flow rate and the effective time of magnetic field exposure. According to Hilal et al. (2013), water that has been exposed to a magnetic field develops a magnetic memory that lasts for 24 to 48 hours. The effectiveness of the magnetic water treatment will therefore depend on the strength of the magnetic field, the makeup of the dissolved salts, and the rate at which the magnetic field is passing the source.

According to the research on this subject, various physiological processes in seedlings may be affected directly or indirectly by changes in the physicochemical parameters of magnetically treated water. As a result, providing plants with magnetically treated water has a gradual impact on their development and growth. According to a number of experts, irrigation water that has previously been exposed to a magnetic field increases plant productivity and alters its water and mineral metabolism. (Maheshwari and Grewal, 2009; Al-Khazan et al., 2011; Abou El-Yazied et al., 2012; Hozayn et al., 2013; Zúñiga et al., 2016). The effacement in the physico-chemical properties appear to influence the biological properties of the organisms (Hassan et al., 2018b, 2018c).

When compared to irrigation with untreated water, using magnetized treated water increased plant growth rate, which is reflected in biomass increase. The stimulatory effect of magnetizing treated water on the growth criteria may be due to its effect on biochemical changes or altered enzyme activities, such as tillering and heading stages for some cereal crops are affected (Nasher, 2008; Celik et al., 2008). The electromagnetic fields increase the Phenylalanine Ammonia-Lyase that the plant growth regulator induces during cell differentiation in the suspended cultured plant cell (Abobatta, 2015). Additionally, plants irrigated with magnetizing treated water easily take up minerals from the soil and leave no residue on the soil surface. Finally, irrigation with magnetizing treated water dramatically lowers the rates of plant disease. As a result, the plants were given the nutrients they needed for the right growth stage and metabolic processes, which led to better rates for all growth parameters and better plant growth. The stimulatory effect of irrigation with magnetized treated water on growth criteria is likely caused by the induction of mitosis and cell metabolism, which speed up all catalytic processes involving oxidation or reduction in this plant. This causes an increase and acceleration of the plant's growth and development activity, which is related to an increase in GA₃, RNA, DNA, and enzyme activities (Amera et al., 2010).

In this case, we can speculate based on our own experience and that of other writers that the magnetic treatment of irrigation water may help ensure the sustainability of water resources by allowing for the use of low-quality water as well as more effective irrigation and water consumption in some crops. Pumpkin and okra seed germination and seedling growth are impacted by magnetic water (Tables 3-8). These might result from varied ways that crops react to magnetic water. Different crops have been found to react differently to the same kind of magnetic water. Our results were supported by 30 Differential response of tomatoes, pepper, cucumber and wheat to magnetic water (Hilal and Hilal, 2000)

CONCLUSION

The use of magnetic water technology is a crucial component in enhancing crop production. In arid and semiarid regions, irrigation water that has been magnetically treated has beneficial effects, and magnetizing treated water can enhance plant growth and development both quantitatively and qualitatively. Additionally, using magnetic water devices can boost water use efficiency, lower soil pH, and increase the mineral content of seeds or fruits. Magnetizing treated water can also be used as a growth-inducing agent. Additionally, adding magnets to treated water had a beneficial, noteworthy impact on the mobility and uptake of micronutrient content. Therefore, we strongly encourage more studies that concentrate on the use of magnetized water technology to improve agricultural operations in water-scarce areas.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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